Medical Research and Control in Air Pollution*

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THE effects of air contaminants on the public health are the subject of widespread interest today. Despite the fact that there has been no extensive clinical or laboratory research in this field, large segments of the population in industrial areas believe their health is being impaired. The Donora incident and repeated accounts of smog attacks in various parts of the United States have increased the public's interests and its fears. More than 50 per cent of the complainants about smog who record their views with officials in Los Angeles County express a firm belief in the hazards to health involved. The aroused public interest and the increase in the release of air contaminants in large industrial centers and densely populated areas have led in the past two years to the creation of several state commissions to study the problem. In numerous instances the public health officer is making the investigation.

In Los Angeles County, where pollution frequently accumulates for prolonged periods because of meteorological conditions, the individual's fear is increased whenever medical opinion attributes a patient's ills to the polluted air. Once this diagnosis has been given, the person receiving the information is convinced. Telephone calls and letters on this subject are a definite problem for the Air Pollution Control District. On days of heavy concentration of smog, what can one tell a mother who believes her children's health is being impaired? What is the answer for an elderly cardiac or respiratory patient who fears he or she will not survive a smog attack? Their pleas for help or some assurance cannot be taken lightly.

Is the answer to be found entirely in a program of research to determine effects? If we assume, as many do, that this research must be done before an alarmed public can be satisfied, we are asking people to wait many years until expensive and time-consuming studies can be completed. Most contaminants are present in the atmosphere at such low concentrations as to make measurements extremely difficult. Where submicron dusts or fumes are involved, more fundamental research is needed before controlled experiments can be undertaken. Considering the time needed to develop methods and the time needed to determine the chronic or long-range hazards of low concentrations of contaminants, one can hardly expect even preliminary answers for some years.

Many discussions on this subject have been held with competent people in Los Angeles County who definitely advocate medical research to answer the question for the public and to insure removal of proved harmful contaminants from the air. Some groups maintain that controls should not be instituted until the effects on health have been determined for each

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TABLE 1

Liquids and Solids

Pollutant	Values in Milligrams Per Cubic Meter: Day of Good Visibility	Values in Milligrams Per Cubic Meter: Day of Reduced Visibility	R.P.I.*: Day of Good Visibility	R.P.I.*: Day of Reduced Visibility
Oily material collected on filter	0.022	0.068	17,200	53,300
Carbon	0.039	0.117	12,000	36,100
Sulfur Trioxide	0.0	0.065	0	30,200
Silicon	0.0025	0.006	793	1,895
Sodium	0.0011	0.0018	789	1,290
Aluminum	0.0025	0.006	536	1,287
Magnesium	0.0011	0.0025	441	1,000
Calcium	0.0025	0.0025	695	695
Iron	0.0025	0.006	221	531
Lead	0.0008	0.006	49	368
Barium	0.0001	0.00024	20	48
Titanium	Trace	0.00024	Trace	37
Chromium	Trace	0.00024	Trace	24
Manganese	Trace	0.00024	Trace	23
Copper	0.0001	0.00024	8	19
Nickel	Trace	0.00024	Trace	19
Boron	Trace	Trace	Trace	Trace
Lithium	Trace	Trace	Trace	Trace
Silver	Trace	Trace	Trace	Trace
Strontium	Trace	Trace	Trace	Trace

* Relative Pollution Index = $NP/10^4$ (NP is the number of particles per cubic meter). NP is determined by: $MG/M^3 = \frac{D^3NP \times Rn}{6 \times 10^9}$

NP is calculated on standard density ($R = \frac{\text{grams}}{\text{cc.}}$) and on an assumed diameter (in microns) which approximates the critical scattering diameter. 0.65 microns (1 micron = 10^{-4} cm.).

pollutant. A certain amount of wishful economic thinking is inherent in the latter proposal. The hope exists that the medical research would only reveal one or two pollutants as affecting public health and that they then could be eliminated at minor cost to industry. A similar oversimplification of the problem is the belief still held by many people in Los Angeles County that one or two pollutants, or one or two types of sources, are the sole cause of the smog problem. Reliance on this belief also enables many contributors to blame "the other fellow" for smog.

The present known results of smog—reduced visibility, eye and throat irritation, damage to crops, and nuisance problems—arise from the discharge of more than fifty different substances which are released to the air in the form of liquid or solid particulate matter, gases and vapors. Reactions occurring in the air such as the formation of sulfuric acid mist from sulfur dioxide and the oxidation of certain hydrocarbons which produce irritating compounds further complicate the mixture in the air. Studies of the health hazard must consider single pollutants and the additive effect or synergistic action of various combinations of contaminants.

In this connection, microchemical techniques have been developed for determining the concentrations on many items of interest in research. The following peak measurements have been obtained in the Los Angeles area (See also Table 1):

Gases and Vapors

Sulfur dioxide	1.0 p.p.m.
Carbon monoxide	20.0 p.p.m.
Oxides of nitrogen	0.38 p.p.m.
Ozone	0.32 p.p.m.
Total aldehydes	0.4 p.p.m.
Total oxidants	0.63 p.p.m.

Formaldehyde	0.25 p.p.m.
Hydrocarbons	1.2 p.p.m.
Cyanides	Negative
Organic acids	0.35
Acetylene	Negative
Acrolein	Negative

Various instruments have been developed for the collection of samples (see Figures 1, 2, and 3). The Beckman aerosol collector for measuring sulfuric acid mist, a large-volume particulate collector and a modified Sonkin impactor are extremely useful tools. Atmospheric pollutants existing in the air as gases and vapors may also be collected by passing air through a series of traps which are immersed in progressively colder freezing mixtures. The first four traps are immersed in a freezing solution at −80° C., followed by a trap immersed in liquid oxygen at −183° C. The traps can be preceded or followed by a mechanical filter if so desired. The greatest collection efficiency is obtained at a sampling rate of 0.1 c.f.m. As the air is drawn through, the gases and vapors are cooled to the point where they condense on the cold surfaces of the traps. Enlarging the condensation surface by a glass wool pack or glass beads will improve the efficiency.

It is not expected that this method can be applied for collection of liquid and solid particles. A dust camera, visibility meter, and continuous aerosol sampler developed by the Chaney Laboratories of Glendale, Calif., have also been used in the air-sampling program.

Fumigation of plants with various contaminants and the study of photochemical reactions are currently under way in a Plexiglas chamber. This sun laboratory will not only provide a means for determining threshold values for irritants but will stimulate the development of analytical methods for further studies of air pollutants.

If medical research were to determine exactly what contaminants should not go into the atmosphere, the control officials would have only two approaches for correcting the problem. The first

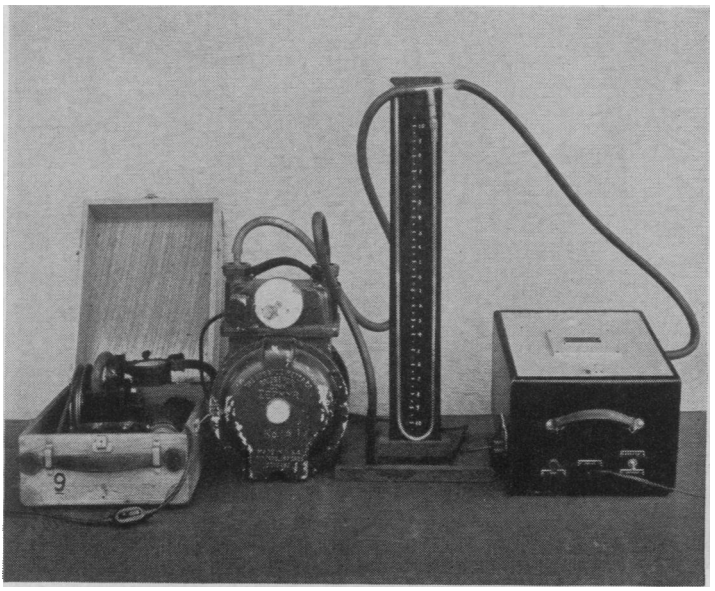

FIGURE 1—Thomas SO_2 Autometer

approach would be reduction of the contaminants at the source to an acceptable level through engineering techniques; the second, eliminating from an area those sources which contribute the forbidden pollutants. If the control must be applied to an even small number of categories, removal of the sources from the area or provisions against the establishment of certain industries are likely to be economically, and probably legally, impossible in an established industrial area until definite proof on the health factor is established. Prohibitions against certain sources entering a community could conceivably be applied only in the beginning stages of industrial growth. The control officer is therefore limited to applying engineering techniques to reduce the pollutants at the source. In this endeavor, he is further limited to the control techniques which are available. For the present, the application of the best available control techniques to smog sources is the maximum effort that anyone can make, regardless of the medical research findings.

What then are the chances for a control program to minimize the pollutants successfully? If the chances are good that controls applied on a broad basis throughout the community will reduce

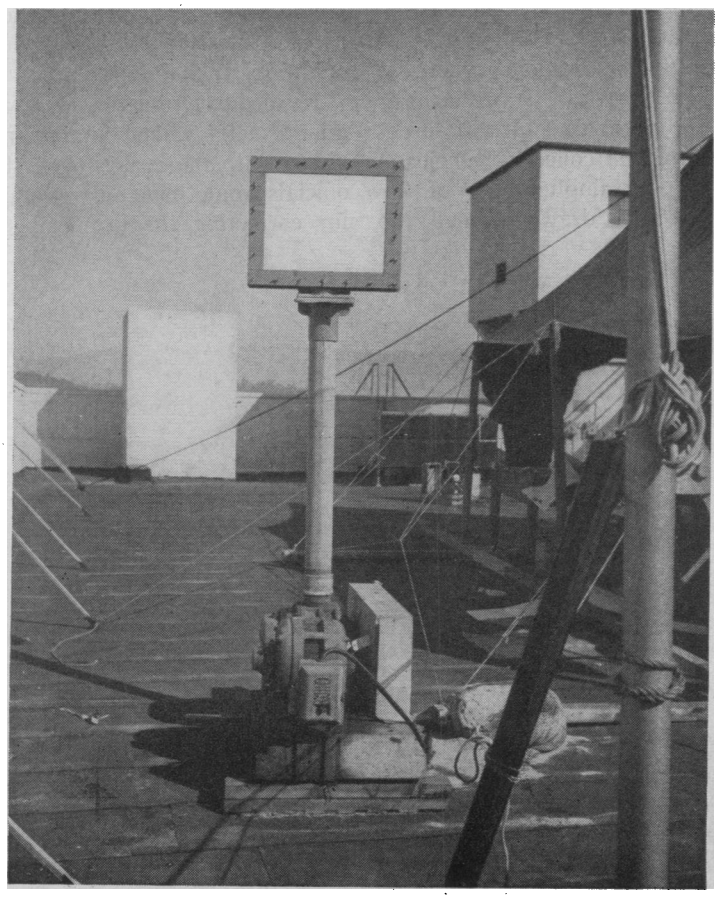

FIGURE 2—Large-Volume Particulate Collector

smog to its lowest possible level, then the public's worries can be allayed by such a program. The experience of the Los Angeles County Air Pollution Control District, while not held up as a model for other areas, may be indicative of what can be expected. A strong, flexible law is available under the California State Health and Safety Code to do the job. The funds have been provided for research to identify pollutants in the atmosphere and those going to the air from various sources in an effort to find the contaminants which produce the observed effects. An Enforcement and Inspection Division is available to seek out the sources and to carry out the enforcement phases of the law. The Engineering staff approves installations of control devices and of basic equipment which *might* pollute the air. An Air Pollution Control Hearing Board has been provided to weigh the equities between the public's right to breathe clean air and the property rights of industry or individuals. This program is planned to take care of the local problem. Research studies are confined to pinpointing pollutants which account for damage to crops, reduce visibility, cause eye irritation, or create local odor or nuisance conditions.

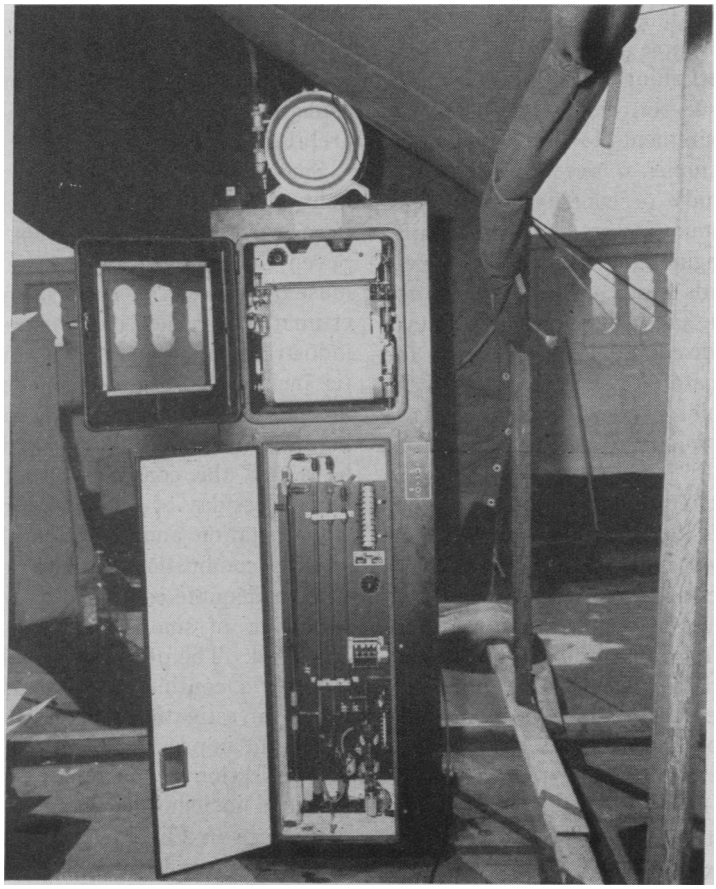

FIGURE 3—Aerosol Collector for SO_3 Determination

Three and a half years of intensive work have resulted in the expenditure by industry of approximately seven and a half million dollars to control pollutants at the source. As potential sources of pollution, industry in Los Angeles County has been divided into 28 categories. In all of these, it can be stated at this time that common visible sources which pollute our air can be effectively controlled. For example, within the metals industry, which in the Los Angeles area includes open-hearth furnaces, electrical furnaces, gray iron cupolas, lead smelters, and other nonferrous activities, metallurgical fumes are being collected with efficiencies ranging from 85 to 99 per cent. The dust producers, which include processes such as grinding and milling, have a relatively simple problem to correct. They are attaining collection efficiencies well above 95 per cent.

The requirements for the collection of dusts and fumes were specified after a detailed study of contributing sources. The economic factors and the availability of engineering techniques to meet the standards were considered before the limits were prescribed. The resultant allowable discharge is based upon the weight of material going into the process. For example, a company processing a thousand pounds of material per hour which results in dust or fume emissions cannot discharge more than 2.8 pounds of such emissions in any hour. This type of regulation is being used only in the Los Angeles area at present and is considered necessary to correct the local problem. Its application to other localities should be considered only after appropriate studies have been made in the area concerned.

The chemical plants producing sulfuric acid have reached the established limit set at 0.2 per cent by volume for sulfur dioxide, which for the present appears to eliminate local crop damage from sulfur dioxide under adverse weather conditions. Sulfur dioxide, produced in the burning of sour gases at refineries, has been reduced by more than 300 tons a day, and the result is the production of valuable sulfur. The burning of fuel oil produces in excess of 250 tons per day of sulfur dioxide, a problem for which no solution exists at present. Continued industrial expansion will increase the tonnage from oil burning. This pollutant must be continually studied to determine whether or not further reduction should be or can be made.

Odor problems, inherent in the operation of rendering plants, fertilizer processors, paint manufacturing and canning industries, have been successfully combated in every instance. Frequently, the improved operations eliminating the odors result in better products or in tangible savings. Oil mists from asphalt plants and strong refinery odors are also being eliminated.

Smoke particles floating in the stagnant air of the Los Angeles basin are most certainly a subject for concern. Seven thousand tons of waste material must be disposed of daily by fire. It is estimated that each day commercial and industrial plants burn 1,000 tons, domestic incinerations, 4,000 tons, municipal incinerators 500 tons, and woodworking plants 1,500 tons. To this activity may be added the consumption of 127,000 barrels per day of petroleum products in transportation and in boiler plants. If all this combustion were to take place with inadequate equipment, several hundred tons of smoke particles would be produced. The prevention of this smoke requires a continuous enforcement program, investigation of operating techniques to improve combustion, and the modernization of antiquated or poorly designed incinerators. It has been the experience in Los Angeles County that industrial smoke can be corrected from these sources. It can be safely stated that this industrial problem has been

reduced by at least 60 per cent. No such rapid progress has been made, however, on public rubbish burning in the county, where from 800,000 to a 1,000,000 back yard incinerators and open fires are potential smokers each day. The solution here involves the establishment of properly designed incinerators or land fill dumps, after which municipally supervised collection can be initiated.

Competent engineering studies on this subject have been completed and the means are at hand for the 46 communities in Los Angeles County to solve their rubbish problem, either as individual cities or by a coöperative plan which links several cities into contiguous rubbish disposal centers.

In addition to the smoke and fly ash found in these combustion gases, it has been determined that these same sources produce 250 tons each day of oxides of nitrogen. While this gas by itself may not be a serious contaminant, its presence in the atmosphere aids the oxidation of unsaturated hydrocarbons which are also present. This oxidation reaction involving unsaturated hydrocarbons, the oxides of nitrogen, and possibly other oxidizing agents produces a complex mixture of organic peroxides, aldehydes, and acids. When this reaction is carried on with extremely low concentrations of the reactants, in the presence of sunlight, certain growing crops exposed to these combined gases show the identical effects which are found in gardens after a smog attack. No other pollutants found in the air have produced this typical smog damage. It therefore appears that with the meterological conditions found in the Los Angeles area, certain hydrocarbons have passed the tolerance level. The next step, of course, is to determine the quantities emitted from the various sources through appropriate tests and studies, as was done in the case of dust, fumes, and smoke. This work is currently under way.

Where successful control has been accomplished with smoke, dust, fumes, and odors, the hope is increased that similar results can be achieved on other pollutants as they are discovered. Claims that this program is unwarranted because of its cost or that the effort to correct the problem is based upon hit-or-miss tactics are not justified. Each source has been studied to determine its contribution to the problem, and controls have been applied, based on the best engineering knowledge at hand. The efforts made in Los Angeles County are paying dividends. The number of days of intense smog is decreasing. Air samples show a decrease in the concentrations of metallic fumes, smoke, other particulates, sulfur dioxide, and sulfur trioxide. The average visibility conditions are improving. Of greater importance is the public's recognition of a noticeable improvement in the situation.

Since the study of sources and contaminants in the atmosphere indicate that neither the health problem nor the general smog problem may be resolved by elimination of one or two contaminants, there is an implication, at least, that some of the less common or more chemically complex waste gases going into the air in many densely populated and industrialized areas have received too little attention and may ultimately require some measure of control. The degree of contamination may be indicated in other areas by any of the symptoms found in Los Angeles, that is, reduced visibility, eye irritation, crop damage, local nuisance problems, and the general complaints of the public. These signs of growing pollution should give rise to timely action before conditions become aggravated. The scope of control and the amount of collection to be applied must be predicated on local studies of the effects, the condition of the atmosphere, and the contributors. Thus a control program based on applying the best knowledge of today offers

the only sound solution to the public's alarm about smog.

These observations do not mean that medical research should be ignored or abandoned. Health authorities agree that more should be known in this field. It would be difficult for one community to shoulder the entire burden of costs and certainly the interest is so widespread that a comprehensive study should receive support from many sources. Perhaps valuable information from medical research could be developed best by a number of separate research studies beginning in the fields where source and air sampling data are available. In this connection, it is of interest to note that federal funds have recently been allotted to a Los Angeles university for studies on lung cancer in the environmental field. Similar grants, such as this, might be sought by many interested researchers across the nation.

Whether the work is to be done piecemeal or in one vast long-range project, there are growing indications that medical research will be undertaken. In the meantime, control programs which are adequately supported to permit studies of each locality and dedicated to measures for the solution of local problems will provide invaluable information and techniques needed by medical researchers.

Three Way Rehabilitation Program

A milestone in the history of physical medicine and rehabilitation is reportedly represented by an agreement of three institutions in New York City to undertake a comprehensive program of teaching research and medical care in this field. The three institutions are the Institute for the Crippled and Disabled, Columbia University, and Presbyterian Hospital. In each of the latter two, a Department of Physical Medicine and Rehabilitation was established at the beginning of 1952, headed in each case by Robert C. Darling, M.D., who is also the chairman of the Medical Board of the Institute for the Crippled and Disabled.

The announced objectives of the affiliated program are:

1. To strengthen the hospital and Institute programs in the rehabilitation and reëducation of the disabled and handicapped.
2. To study and improve methods of rehabilitation and reëducation.
3. To provide a joint research and teaching program.
4. To provide jointly, "in proper continuity," all the professional services required by a handicapped person—including medical, psychosocial, vocational, industrial, and recreational.
5. To provide for the reciprocal interchange and utilization of the institutions' facilities.

Emphasized particularly will be research aimed at the development of new and improved prosthetic devices.